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Experiences of reprocessing plutonium rich mixed carbide fuels

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The mixed carbide (70% Pu, 30% U) spent fuel from the Fast Breeder Test Reactor (FBTR) at Kalpakkam, India is being reprocessed at the CORAL facility since 2003. Several campaigns with progressively increasing burnups and reducing cooling periods have been carried out in this facility. Presently spent fuels with a burn up of 155 GWd/Te with cooling periods as around two years are being reprocessed. The satisfactory operation of this facility has provided valuable inputs for the design of process, equipment and other systems. Sustained operation of critical process equipment such as chopper, dissolver and solvent extraction equipment enabled in the fine tuning of design for reliable operation and easier maintenance.

Design optimization for the future plants DFRP and FRP which are under construction for closing the fuel cycle of FBTR and Prototype Fast Breeder Reactor (PFBR) respectively could be carried based on the operating experience with single pin chopper. The apprehension that mixed carbide fuel would be difficult to dissolve and not give a satisfactory solvent extraction performance, is alleviated by the experience of quantitative dissolution and recovery of plutonium. Typical hull losses have been experimentally found to be less than 0.08% for plutonium. Though some carbide carbon was found to be there in the dissolver solution, it does not affect the solvent extraction performance. The highly oxidative dissolution conditions required for the dissolution of the spent fuel, call for material of construction other than the conventional stainless steel, as its corrosion rate of under such condition is unacceptably high. Alternate material of construction has been identified and deployed for the CORAL dissolver. Inspection of the dissolver after around three years of operation has revealed satisfactory performance. Though three solvent extraction cycles have been provided in the plant, it has been found that the required decontamination could be achieved with a single cycle. Typical decontamination factors of greater than 10**3 for Ru-106 and 10**4 for Cs-137 have been achieved. The recovery of plutonium and uranium are greater than 99.9% and 99.8% respectively. The centrifugal extractors have provided extremely satisfactory performance with progressive improvement in the performance in terms of reduced maintenance requirements with incorporation of design changes during the campaigns.

R&D work has been concurrently taken up based on the performance evaluation of the facility for improving the recovery, decontamination factors, economy and reducing the waste volumes. With the computer code PUSEP(Ver-II) developed by the reprocessing group, IGCAR, an innovative extraction flowsheet is formulated to meet the decontamination requirements of both 95Zr and 106Ru while reprocessing fuels with less than two years cooling period. With this code it has been possible to establish the flow rate controls required for avoiding the third phase formation due to excessive plutonium loading in the solvent phase. Also, it has been found that closer to the stoichiometric requirement of uranous for separation of plutonium from uranium is possible. These findings will substantially reduce the number of solvent extraction cycles and hence the waste volumes.

Reduction of solvent waste using vacuum distillation and the removal of dissolved organic by diluent wash using efficient contactors to address the red-oil formation during waste evaporation, are a few R&D activities in progress to improve the plant performance.

Another important offshoot of the operation of the CORAL facility is the development of a variety of hot cell equipment and systems for remote operation and maintenance with least plutonium contamination in the operating area.

Based on the satisfactory experience, it is expected that the reprocessing of PFBR spent MOX fuel would not pose a challenging problem as the plutonium content in PFBR is much less (around 25%).

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